Serial No.: 10/797,032

IN THE SPECIFICATION:

Page 1, line 3 to Page 2, line 9, please amend as follows:

The present invention relates to a ~~gasdynamic~~ gas dynamic bearing used in a small spindle motor of a hard disk drive or the like.

BACKGROUND ART

A high precision and high speed rotation have increasingly been requested, heretofore, in a spindle motor used in a hard disk drive along with realization of a higher density and higher speed data transmission in the hard disk drive. In recent years, a dynamic pressure oil bearing motor has been employed as a technique of serving for such a request. There has also been studied a ~~gasdynamic~~ gas dynamic bearing motor capable of a high speed rotation without scattering of oil or degradation of oil.

A gas has a viscosity lower than oil and a compressible fluid; therefore, a ~~gasdynamic~~ gas dynamic bearing has a low load capacity per a unit area of the bearing, which inevitably requires a larger scale as compared with a dynamic oil bearing.

If a ~~gasdynamic~~ gas dynamic bearing was constructed within a small motor used for a spindle of a hard disk drive, it would be hard to obtain a sufficient bearing stiffness. Hence, since a diameter of a radial bearing necessary to be the largest possible value, various constructions have been investigated in order to enhance a bearing stiffness.

In Fig. 17, there is shown a sectional view of an example of a conventional ~~gasdynamic~~ gas dynamic bearing. A stationary shaft 91 is constructed of a cylindrical shaft 1 and a ring-shaped thrust plate 2 fixed on the upper end of the shaft 1, wherein the lower end of the stationary shaft 91 is fixed to a base 7a. A lidded cylindrical hub 3d is fitted with an outer circumferential surface 81 of the shaft 1 and an upper surface 85 of the thrust plate 2 so as to surround them with a predetermined clearance interposed therebetween. Inserted and fixed in a central hole of the hub 3d is a pin 4 with a magnet 5 fixed at the lower portion thereof and a flange 41 in the middle portion thereof, and a rotor assembly 92 is constructed of the hub 3d, the pin 4 and the magnet 5 combined. A flange-shaped disk receiving portion 31d extending outwardly in a radial

direction is provided at the lower end of the hub 3d, on which recording disks 9 and spacers 10 are loaded and fixed by screwing a clamp 8 at the top thereof into the hub 3d.

Page 3, line 16 to Page 5, line 20, please amend as follows:

In a ~~gasdynamic~~ gas dynamic bearing motor as in the conventional examples described above, a diameter of a radial bearing has been set to the largest possible value in order to obtain a sufficient radial bearing stiffness; therefore, there has been a trend toward a smaller thickness of the hub 3d, which is a difference in radius between the inner circumferential surface and outer circumferential surface of the hub 3d. Consequently, a large force acts on a disk receiving portion when the recording disks 9 are loaded on the hub 3d and fixed with the clamp 8; therefore, the hub 3d deforms so that the lower end portion of the inner circumferential surface of the hub 3d is bent inwardly.

In a conventional ~~gasdynamic~~ gas dynamic bearing motor, machining of parts has been made so that the outer circumferential surface of the shaft 1 and the inner circumferential surface of the hub 3d face each other with a predetermined clearance interposed therebetween in the state where no recording disk 9 is loaded on the hub 3d. Therefore, the clearance between the outer circumferential surface of the shaft 1 and the inner circumferential surface of the hub 3d becomes narrower in the lower end portion of the radial bearing when the recording disks 9 are loaded on the hub 3d for assembly, resulting in occurrence of partial contact, generation of abrasive wear and lock of the bearing.

Wear powder generated by friction on bearing surfaces scatters outside the motor through a clearance between the base and the lower end surface of the hub to contaminate the interior of the hard disk drive.

DISCLOSURE OF THE INVENTION

The present invention solves the problems and it is an object of the present invention to provide a ~~gasdynamic~~ gas

dynamic bearing motor capable of: restricting deformation of an inner circumferential surface of a rotor assembly on which a recording disk is loaded to a small value even in a case where a diameter of a radial bearing is set to a large value in order to obtain a sufficient radial bearing stiffness to thereby thin a thickness of the rotor assembly; suppressing partial contact, which has occurred conventionally in the lower end portion of an inner circumferential surface of the rotor assembly to thereby prevent abrasion wear and lock of the bearing; and further, of preventing wear powder generated by friction between bearing surfaces from scattering outside a motor through a clearance between a base and a lower end surface of a hub.

In order to solve the problems, a ~~gasdynamic~~ gas dynamic bearing motor of the present invention includes a stationary shaft having a cylindrical surface and a rotor assembly having a cylindrical portion facing the stationary shaft with a predetermined clearance interposed therebetween in a radial direction of the stationary shaft and freely rotatably fitted with the stationary shaft, wherein a pressure generating groove is formed on at least one of an outer circumferential surface of

the stationary shaft and an inner circumferential surface of the rotor assembly to thereby construct a radial bearing, a flange-shaped disk receiving portion extending outwardly in a radial direction is provided at the lower end of the rotor assembly, a predetermined number of recording disks are loaded on the disk receiving portion, a clamp is disposed on the uppermost portion and fixed to the rotor assembly to squeeze the recording disks between the disk receiving portion and the clamp with a predetermined force for fixation of the recording disks, and then, the rotor assembly is rotated by a driving motor to hold the rotor assembly and the recording disks in a non-contact manner with the stationary shaft with the action of a dynamic pressure of a gas residing in a clearance between the stationary shaft and the rotor assembly. The ~~gasdynamic~~ gas dynamic bearing motor is characterized in that an annular groove is provided on an end surface of the disk receiving portion side of the rotor assembly coaxially with the stationary shaft.

Page 6, lines 6-15, please amend as follows:

The ~~gasdynamic~~ gas dynamic bearing motor of the present invention is also characterized in that an outer diameter of the stationary shaft is constant in an axial direction thereof, while a diameter of the inner circumferential surface of the rotor assembly changes in an axial direction thereof when no recording disk is loaded on the disk receiving portion so that a clearance between the outer circumferential surface of the stationary shaft and the inner circumferential surface of the rotor assembly is almost constant in the axial directions thereof when the recording disks are loaded on the disk receiving portion.

Page 6, line 29 to Page 7, line 6, please amend as follows:

The ~~gasdynamic~~ gas dynamic bearing motor of the present invention is also characterized in that an inner diameter of the rotor assembly is constant in the axial direction thereof, while

a diameter of the outer circumferential surface of the stationary shaft changes in the axial direction thereof so that a clearance between the outer circumferential surface of the stationary shaft and the inner circumferential surface of the rotor assembly is almost constant in the axial directions thereof when the recording disks are loaded on the disk receiving portion.

Page 7, lines 20-25, please amend as follows:

The ~~gasdynamic~~ gas dynamic bearing motor of the present invention is also characterized in that a protrusion is provided on the base in a circumferential direction thereof and fitted in the annular groove provided on the rotor assembly with a predetermined clearance interposed therebetween to thereby construct a labyrinth seal.

Page 8, line 2 to Page 9, line 24, please amend as follows:

Fig. 1 is a sectional view of a ~~gasdynamic~~ gas dynamic bearing in Embodiment 1 of the present invention;

Fig. 2 is a side view of a shaft of the ~~gasdynamic~~ gas dynamic bearing;

Fig. 3A is a upper surface view of a thrust plate of the ~~gasdynamic~~ gas dynamic bearing;

Fig. 3B is a lower surface view of the thrust plate of the ~~gasdynamic~~ gas dynamic bearing;

Fig. 4 is an enlarged sectional view of a part in the vicinity of a disk receiving portion of the ~~gasdynamic~~ gas dynamic bearing;

Fig. 5 is a graph showing sectional shapes of the inner circumferential surface of a hub when recording disks are loaded and when no recording disk is loaded in the ~~gasdynamic~~ gas dynamic bearing;

Fig. 6 is a graph showing a relationship between a depth of an annular groove and a deformation amount of a lower end portion of a hub in the ~~gasdynamic~~ gas dynamic bearing;

Fig. 7 is a graph showing a relationship between a difference between an outer radius r1 of the hub and a radius r2 of an inner wall of a groove inwardly in a radial direction thereof (r1 - r2), and a deformation amount of a lower end portion of the hub in the ~~gasdynamic~~ gas dynamic bearing;

Fig. 8 is a sectional view of a ~~gasdynamic~~ gas dynamic bearing in Embodiment 2 of the present invention;

Fig. 9 is a sectional view of another ~~gasdynamic~~ gas dynamic bearing in Embodiment 2 of the present invention;

Fig. 10 is a sectional view of still another ~~gasdynamic~~ gas dynamic bearing in Embodiment 2 of the present invention;

Fig. 11 is a graph showing sectional shapes of an inner circumferential surface of a hub when recording disks are loaded and when no recording disk is loaded in the ~~gasdynamic~~ gas dynamic bearing shown in Fig. 8;

Fig. 12 is a graph showing sectional shapes of an inner circumferential surface of a hub when recording disks are loaded and when no recording disk is loaded in the ~~gasdynamic~~ gas dynamic bearing shown in Fig. 9;

Fig. 13 is a graph showing sectional shapes of an inner circumferential surface of a hub when recording disks are loaded and when no recording disk is loaded in the ~~gasdynamic~~ gas dynamic bearing shown in Fig. 10;

Fig. 14 is a sectional view of a ~~gasdynamic~~ gas dynamic bearing in Embodiment 3 of the present invention;

Fig. 15 is a sectional view of another ~~gasdynamic~~ gas dynamic bearing in Embodiment 3 of the present invention;

Fig. 16 is a sectional view of still another ~~gasdynamic~~ gas dynamic bearing in Embodiment 3 of the present invention; and

Fig. 17 is a sectional view of a conventional ~~gasdynamic~~ gas dynamic bearing.

EMBODIMENTS

(Embodiment 1)

Description will be given of a first embodiment of the present invention using Figs. 1 to 7 below. Fig. 1 is a sectional view of a ~~gasdynamic~~ gas dynamic bearing of the present invention. Fig. 4 shows an enlarged sectional view of a

part in the vicinity of a disk receiving portion of the ~~gasdynamic~~ gas dynamic bearing.

Page 13, line 8-27, please amend as follows:

As a ~~gasdynamic~~ gas dynamic bearing motor for a hard disk drive, a clearance between the outer circumferential surface 81 of the shaft 1 and the inner circumferential surface 82 of the hub 3 is preferably set on the order of a value in the range from 3 μm to 5 μm, and it is further required that in order to prevent abrasive wear due to partial contact in the lower end portion and lock of the bearing, which have occurred conventionally, a deformation of the lower end portion of the inner circumferential surface 82 of the hub 3, inwardly in the radial direction thereof, is at most equal to or less than one half of the clearance between the outer circumferential surface of the shaft 1 and the inner circumferential surface 82 of the hub 3 in consideration of the machining precision of the shaft 1 or the hub 3. In the motor shown in Fig. 1, since a clearance between the outer circumferential surface 81 of the shaft 1 and

the inner circumferential surface 82 of the hub 3 is set to 3 μm, a deformation amount of the lower end portion of the inner circumferential surface 82 of the hub 3, inwardly in a radial direction thereof, is preferably set to a value of about 1.5 μm or less.

Page 15, lines 5-12, please amend as follows:

In Figs. 8 to 13, there are shown sectional views of examples of a second embodiment of the present invention. Note that the same marks are attached to the same constituents of the construction of a dynamic gas bearing motor as those in the above embodiment; therefore, description thereof will not be repeated. Note that the shapes and dimensions in the ~~gasdynamic~~ gas dynamic bearing motor in this embodiment are almost the same as in the ~~gasdynamic~~ gas dynamic bearing motor in Embodiment 1.

Page 17, lines 15-21, please amend as follows:

In Figs. 14 to 16, there are shown examples of a third embodiment of the present invention. Note that the same marks are attached to the same constituents of the construction as in the dynamic gas bearing in the above embodiments; therefore, descriptions thereof will not be repeated. Shapes and dimensions therein are almost the same as those in the ~~gasdynamic~~ gas dynamic bearing motor in Embodiment 1.

Page 18, lines 20-30, please amend as follows:

According to a ~~gasdynamic~~ gas dynamic bearing motor of the present invention, as described above, even in a case where a diameter of a radial bearing is set to a large value to thereby thin a thickness of a hub in order to obtain a sufficient radial bearing stiffness, it is possible to restrict deformation of the hub when recording disks are loaded on the hub to a small value by an annular groove provided on the lower end surface of the

hub, thereby enabling suppression of partial contact that is caused by inward deformation of the lower end portion of the inner circumferential surface of the hub, which has occurred conventionally, in the lower end portion of the bearing and, in turn, prevention of abrasive wear and lock of the bearing.